2017

Realizing the potential of cancer prevention - the role of implementation science

Karen M. Emmons
Harvard University

Graham A. Colditz
Washington University School of Medicine in St. Louis

SOUNDING BOARD

Realizing the Potential of Cancer Prevention — The Role of Implementation Science

Karen M. Emmons, Ph.D., and Graham A. Colditz, M.D., Dr.P.H.

In the past two decades, we and others have estimated that more than half of cancers could have been prevented by applying knowledge that we already have. Tobacco use, inactivity, and obesity are modifiable causes of cancer,[1-3] and evidence now suggests that vaccination against the human papillomavirus, the use of aspirin and selective estrogen-receptor modulators, and participation in screening programs further reduce the risk of specific cancers.[4,5] The effect of these strategies on cancer-related outcomes in the general population is significant. A 62% reduction in lung-cancer mortality is associated with smoking cessation at age 50,[6] and environmental and policy strategies are effective at increasing cessation.[6-8] A 95% reduction in mortality is associated with screening for cervical cancer,[9] a 100% reduction in mortality is associated with vaccination against the human papillomavirus,[10-12] and a 90% reduction in mortality related to chronic liver disease and liver cancer is associated with vaccination against hepatitis B virus.[13] There is also benefit for those at high risk for cancer. Lung-cancer screening is associated with a 20% reduction in mortality among smokers at high risk, salpingo-oophorectomy reduces the risk of breast and ovarian cancer among women with a *BRCA1/2* mutation,[14,15] and treatment with selective estrogen receptor modulators reduces the incidence of breast cancer by 50% among women at high risk.[16,17] Screening, diagnosis, and treatment of hepatitis C virus infection reduces the risk of all-cause mortality by 50% among those with infection.[18] Our ability to prevent cancer has improved significantly.

HOW WELL DO WE USE THE EVIDENCE ON CANCER PREVENTION?

The evidence on cancer prevention has not been adopted in the United States as effectively as it might have been (Table 1). Among the strategies for the prevention of cancer, smoking cessation has the longest-standing evidence base. Environmental and policy approaches (e.g,. taxation and restrictive policies) that reduce the rate of risky behaviors and that increase access to treatment are particularly important for tobacco control at the population level.[6-8,26] However, the current federal excise tax on tobacco, $1.01, is low as compared with the average of about $3.15 per pack in high-income countries worldwide. There is often statistically significant variation among the states in the implementation of the evidence base. One example is state tobacco taxes, which range from 17 cents to $4.35 per pack of cigarettes.[27] Raising cigarette excise taxes at the state and federal levels is viewed as a key strategy in reducing smoking prevalence, yet almost one third of states have not raised their taxes in 10 years. Long-standing gaps in access to cessation treatment were addressed in the Affordable Care Act (ACA),[28,29] which is now at risk.

Similar gaps in the implementation of the evidence base can be seen in nearly all known cancer-prevention strategies. Simply put, as a nation, we continue to underinvest in primary prevention and screening and fail to adopt strategies to ensure that all population groups benefit equally from our knowledge of cancer prevention. As a result, cancer morbidity and mortality are unnecessarily high,[30] and these high rates translate into huge health care costs and a devastating burden for patients and their families.[31,32] Prevention is much less expensive. For example, the economic cost of smoking is estimated at $300 billion a year.[33] Every $1 expended on a comprehensive smoking-cessation program in Massachusetts was associated with a return on investment of $2.12.[34]

HOW CAN WE MAXIMIZE THE USE OF EXISTING EVIDENCE?

If we wish to increase the use of the existing evidence on cancer prevention, it is imperative

Table 1. Prevalence of Factors That Modify the Risk of Cancer in the United States.*

Risk Modifiers	Average National Prevalence, 2014 and 2015	States with Highest and Lowest Prevalence		Source
		Highest	Lowest	
		percent		
Cigarette smoking				
Adult	15.1 (2014)	West Virginia, 26.7	Utah, 9.7	Data on national prevalence[19] and statewide prevalence[20] are from the CDC.
Youth	10.8 (2014)	West Virginia, 18.8	Utah, 4.4	All data are from the CDC.[21]
BMI ≥30†	29.8 (2014)	Louisiana, 36.2	Colorado, 20.2	Data are from the CDC.[22]
Lack of physical activity‡	22.1 (2014)	Mississippi, 31.4	Colorado, 16.4	Data are from the CDC.[22]
Fruit intake (≥2 cups/day)	13.1 (2013)	California, 17.7	Tennessee, 7.5	Data are from Moore and Thompson.[23]
Vegetable intake (2.5–3 cups/day	8.9 (2013)	California, 13.0	Mississippi, 5.5	Data are from Moore and Thompson.[23]
Screening for colon cancer§	66.4 (2014)	Massachusetts, 76.5	Wyoming, 56.9	Data are from the CDC.[20]
Mammography¶	73.0 (2014)	Massachusetts, 82.1	Idaho, 62.5	Data are from the CDC.[20]
Pap test‖	82.6 (2014)	Massachusetts, 88.0	Idaho, 76.2	Data are from the CDC.[20]
HPV vaccination**	Girls: 41.9 Boys: 28.1 (2015)	Girls: Rhode Island, 68.0 Boys: Rhode Island, 58.1	Girls: Mississippi, 24.4 Boys: Tennessee, 16.0	Data are from Reagan-Steiner et al.[24]
HBV vaccination††	72.4 (2014)	North Dakota, 88.4	Vermont, 48.4	Data are from Hill et al.[25]

* CDC denotes Centers for Disease Control and Prevention.
† BMI denotes body-mass index, calculated as the weight in kilograms divided by the square of the height in meters. Some organizations now classify obesity as a BMI of 30 or higher.
‡ The lack of physical activity is defined as no leisure-time physical activity among persons 18 years of age or older.
§ The percentages for colon-cancer screening are based on persons between 50 and 75 years of age for whom the screening met the recommendations of the U.S. Preventive Services Task Force.
¶ Data on mammography are from women 40 years of age or older who had a mammogram within the preceding 2 years.
‖ Data on the Papanicolaou (Pap) test are from women 21 to 65 years of age who had a Pap test within the preceding 3 years.
** These children received at least three vaccinations against the human papillomavirus (HPV).
†† Vaccinations against hepatitis B virus (HBV) were administered from birth through the age of 3 days.

that we conduct more dissemination research and implementation research focused on cancer prevention. Dissemination research is the systematic study of processes and factors that lead to the widespread use of an evidence-based practice.[35] Implementation research focuses on understanding the processes and factors that are associated with the successful integration of evidence-based practices in a particular setting (e.g., a primary care clinic or school) and on evaluating the effects of any adaptations of the practices that are needed in that setting. Together, these two approaches, supported by strong and growing methods, can help us bend the curve on the use of evidence on cancer prevention. Dissemination and implementation research focused on the strategies needed to enhance population-level cancer prevention may be particularly productive.[26]

Environmental and policy initiatives can reach a large number of people efficiently.[6-8] Dissemination and implementation research can help to elucidate organizational factors that may speed implementation differentially across settings. For example, worksite smoking bans and comprehensive smoking-cessation programs have been effective strategies for reducing smoking among adults,[7] and the organizational characteristics associated with the adoption of smoking bans have been identified.[36,37] Future opportunities for

policy interventions might focus on areas where there has been resistance to the adoption of evidence-based strategies, such as states with low excise taxes or limited implementation of restrictive smoking policies, as noted above. Environments that provide access to groups with an elevated prevalence of risk-related behaviors are another important target. For example, higher rates of implementation of evidence-based tobacco-control interventions are needed in settings that provide care to people with mental health and substance-abuse issues, since the prevalence of smoking in these two groups is much greater than that in the general population.[38] Only 35% of substance abuse treatment facilities[39] have a smoking ban, only about half provide any counseling or medication for smoking cessation,[40] and psychiatrists deliver cessation counseling to patients who smoke at only 12% of visits.[41] Despite the demonstrated efficacy of smoking-cessation treatment in the context of mental health care, only 13 states require provision of cessation treatment in facilities that provide treatment for alcohol abuse, drug abuse, or other conditions related to mental health.[42] It is likely that the facilitators of the adoption of antismoking policies are different in treatment centers and the workplace. Dissemination and implementation research can help to determine how to increase the use of smoking bans and the provision of comprehensive treatment in these settings, as can changes in state and federal policy that provide protection from exposure to secondhand smoke and ensure access to cessation treatment.

The setting in which cancer is treated is another important target for increasing the use of evidence on cancer prevention. The 2014 Surgeon General's report concludes that there is a causal relationship between smoking and adverse health outcomes and mortality among people with cancer and that all-cause mortality could be lowered in such people by 30 to 40% if they would stop smoking at the time of diagnosis.[7] Reasoning by analogy, a cancer center that did not use evidence-based chemotherapy protocols would not be competitive for funding from the National Cancer Institute. Applying the same expectation for the evidence-based treatment of behavioral risk factors among people with known cancer could accelerate the reduction in the risk of death for the 13 million cancer survivors in the United States and thereby benefit not only patients but their families and caregivers. Dissemination and implementation research should focus on improving our understanding of the factors at the provider, patient, organizational, and policy levels that impede the adoption of evidence-based cancer-prevention strategies.

Increased population-level access to cancer prevention can also be achieved by focusing research efforts across multiple levels of influence, often through new and nontraditional partnerships. As the examples above illustrate, there is a need for both policies that encourage behaviors related to risk reduction and access to evidence-based treatments. If the ACA is largely repealed, access to evidence-based treatment will be reduced or eliminated for millions of smokers. Access to cancer-screening services will also be reduced. Other avenues of access must be created. The Center for Medicare and Medicaid Services (CMS) could use its innovation awards to aid the development of new strategies that would provide access to screening services and to expand the use of evidence-based cancer-prevention strategies, as it has done in helping to reduce the risk of cardiovascular disease. It would be valuable to determine whether state-level efforts lead to outcomes that are different from those supported by CMS investment, whether CMS resources could be used to advance state-level efforts to boost the implementation of evidence-based research, and whether partnerships with parties whose focus is not health care (e.g., schools, churches, and government agencies such as agriculture and housing) could help to increase use. In collaboration with the National Institutes of Health and the Centers for Disease Control and Prevention, targeted research opportunities could be created to maximize the knowledge gained.

Social determinants contribute to disparities in cancer morbidity and mortality.[43] Organizations that serve communities with limited economic resources, such as safety-net health centers, have a particular role to play in ensuring equitable access to cancer-prevention programs. However, given limited resources and high demand, it can be difficult to integrate new practices into such organizations. Initial work suggests that some of the characteristics of an organization or community (e.g., the willingness of leaders to engage, tension with regard to change or a perception

that the current situation is intolerable, and the presence of formally appointed implementation leaders), in addition to characteristics of the intervention itself, differentiate systems that adopt evidence-based practices from lower-performing systems.[44,45] Research is needed that incorporates the full range of factors that influence implementation in areas that serve populations with a high cancer burden and limited resources.[46]

CONCLUSIONS

If we are to benefit as a nation from our investment in cancer research, it is imperative that we focus on strategies that will reduce the variation in the implementation of effective cancer-prevention programs. We have much to learn from organizations and communities that make greater use of prevention-focused policies, and we need to broaden our understanding of the social, political, and environmental factors that favor the implementation of evidence-based programs.[47] If our efforts to reduce the cancer burden are to go beyond rhetoric, they must address the factors involved in implementation that account for disparities in outcome and have the greatest effect on populations with the largest cancer burden. When we implement evidence-based prevention and screening programs correctly and at scale, we achieve substantial population benefits. Although many efforts are under way to maximize our knowledge about the causes and treatments of cancer, we can achieve reductions in the cancer burden right now by doing what we already know works. Enhanced investment in research that increases our understanding of how to implement the knowledge we have is needed. Our moonshot is right here — ready for the taking.

Disclosure forms provided by the authors are available with the full text of this article at NEJM.org.

Drs. Emmons and Colditz contributed equally to this article.

From the Harvard T.H. Chan School of Public Health, Boston (K.M.E.); and the Division of Public Health Sciences, Washington University School of Medicine, St. Louis (G.A.C.). Address reprint requests to Dr. Colditz at the Division of Public Health Sciences, Washington University School of Medicine, 660 S. Euclid Ave., St. Louis, MO 63110, or at colditzg@wudosis.wustl.edu.

1. Willett WC, Colditz GA, Mueller NE. Strategies for minimizing cancer risk. Sci Am 1996;275:88-91, 94-5.
2. Colditz GA, DeJong D, Emmons K, Hunter DJ, Mueller N, Sorensen G. Harvard report on cancer prevention. Volume 2: prevention of human cancer. Cancer Causes Control 1997;8: Suppl 1:S1-S50.
3. Doll R, Peto R. The causes of cancer: quantitative estimates of avoidable risks of cancer in the United States today. J Natl Cancer Inst 1981;66:1191-308.
4. Colditz GA, Wolin KY, Gehlert S. Applying what we know to accelerate cancer prevention. Sci Transl Med 2012;4:127rv4.
5. U.S. Preventive Services Task Force. Screening for colorectal cancer: U.S. Preventive Services Task Force recommendation statement. Ann Intern Med 2008;149:627-37.
6. Koh HK, Sebelius KG. Ending the tobacco epidemic. JAMA 2012;308:767-8.
7. The health consequences of smoking — 50 years of progress: a report of the Surgeon General. Atlanta: Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health, 2014 (https://www.surgeongeneral.gov/library/reports/50-years-of-progress/).
8. Chaloupka FJ, Yurekli A, Fong GT. Tobacco taxes as a tobacco control strategy. Tob Control 2012;21:172-80.
9. Screening for squamous cervical cancer: duration of low risk after negative results of cervical cytology and its implication for screening policies: IARC Working Group on evaluation of cervical cancer screening programmes. Br Med J (Clin Res Ed) 1986; 293:659-64.
10. Brotherton JM, Fridman M, May CL, Chappell G, Saville AM, Gertig DM. Early effect of the HPV vaccination programme on cervical abnormalities in Victoria, Australia: an ecological study. Lancet 2011;377:2085-92.
11. Gertig DM, Brotherton JM, Budd AC, Drennan K, Chappell G, Saville AM. Impact of a population-based HPV vaccination program on cervical abnormalities: a data linkage study. BMC Med 2013;11:227.
12. Giuliano AR, Palefsky JM, Goldstone S, et al. Efficacy of quadrivalent HPV vaccine against HPV Infection and disease in males. N Engl J Med 2011;364:401-11.
13. Chiang CJ, Yang YW, You SL, Lai MS, Chen CJ. Thirty-year outcomes of the national hepatitis B immunization program in Taiwan. JAMA 2013;310:974-6.
14. Rebbeck TR, Kauff ND, Domchek SM. Meta-analysis of risk reduction estimates associated with risk-reducing salpingo-oophorectomy in BRCA1 or BRCA2 mutation carriers. J Natl Cancer Inst 2009;101:80-7.
15. Bevers TB, Ward JH, Arun BK, et al. Breast cancer risk reduction, version 2.2015. J Natl Compr Canc Netw 2015;13:880-915.
16. Fisher B, Costantino JP, Wickerham DL, et al. Tamoxifen for the prevention of breast cancer: current status of the National Surgical Adjuvant Breast and Bowel Project P-1 study. J Natl Cancer Inst 2005;97:1652-62.
17. Martino S, Cauley JA, Barrett-Connor E, et al. Continuing outcomes relevant to Evista: breast cancer incidence in postmenopausal osteoporotic women in a randomized trial of raloxifene. J Natl Cancer Inst 2004;96:1751-61.
18. CDC Fact sheet: viral hepatitis and liver cancer. Atlanta: Centers for Disease Control and Prevention, Department of Health and Human Services, 2016.
19. Ward B, Clarke T, Nugent C, Schiller JT. Early release of selected estimates based on data From the 2015 National Health Interview Survey. Atlanta: National Center for Health Statistics, May 2016 (https://www.cdc.gov/nchs/data/nhis/earlyrelease/earlyrelease201605.pdf).
20. Centers for Disease Control and Prevention. BRFSS Prevalence and Trends data. 2016 (https://www.cdc.gov/brfss/brfssprevalence/index.html).
21. Centers for Disease Control and Prevention. Youth Risk Behavior Surveillance System data. 2016 (https://nccd.cdc.gov/youthonline/App/Default.aspx).
22. Centers for Disease Control and Prevention. Chronic Disease Indicators (CDI) data. 2016 (http://nccd.cdc.gov/cdi).
23. Moore LV, Thompson FE. Adults meeting fruit and vegetable intake recommendations — United States, 2013. MMWR Morb Mortal Wkly Rep 2015;64:709-25.

24. Reagan-Steiner S, Yankey D, Jeyarajah J, et al. National, regional, state, and selected local area vaccination coverage among adolescents aged 13–17 years — United States, 2015. MMWR Morb Mortal Wkly Rep 2016;65:850-8.
25. Hill HA, Elam-Evans LD, Yankey D, Singleton JA, Kolasa M. National, state, and selected local area vaccination coverage among children aged 19–35 months — United States, 2014. MMWR Morb Mortal Wkly Rep 2015;64:889-96.
26. Brownson RC, Haire-Joshu D, Luke DA. Shaping the context of health: a review of environmental and policy approaches in the prevention of chronic diseases. Annu Rev Public Health 2006;27:341-70.
27. Boonn A. State cigarette excise tax rates & rankings. Washington, DC: Campaign for Tobacco-Free Kids, 2016 (http://www.tobaccofreekids.org/research/factsheets/pdf/0097.pdf).
28. Fiore MC, Jaén CR. A clinical blueprint to accelerate the elimination of tobacco use. JAMA 2008;299:2083-5.
29. McAfee T, Babb S, McNabb S, Fiore MC. Helping smokers quit — opportunities created by the Affordable Care Act. N Engl J Med 2015;372:5-7.
30. Byers T, Wender RC, Jemal A, Baskies AM, Ward EE, Brawley OW. The American Cancer Society challenge goal to reduce US cancer mortality by 50% between 1990 and 2015: results and reflections. CA Cancer J Clin 2016;66:359-69.
31. Altice CK, Banegas MP, Tucker-Seeley RD, Yabroff KR. Financial hardships experienced by cancer survivors: a systematic review. J Natl Cancer Inst 2016;109(2):djw205.
32. Mariotto AB, Yabroff KR, Shao Y, Feuer EJ, Brown ML. Projections of the cost of cancer care in the United States: 2010-2020. J Natl Cancer Inst 2011;103:117-28.
33. Xu X, Bishop EE, Kennedy SM, Simpson SA, Pechacek TF. Annual healthcare spending attributable to cigarette smoking: an update. Am J Prev Med 2015;48:326-33.
34. Richard P, West K, Ku L. The return on investment of a Medicaid tobacco cessation program in Massachusetts. PLoS One 2012;7(1):e29665.
35. Rabin BA, Glasgow RE, Kerner JF, Klump MP, Brownson RC. Dissemination and implementation research on community-based cancer prevention: a systematic review. Am J Prev Med 2010;38:443-56.
36. Emmons KM, Thompson B, McLerran D, et al. The relationship between organizational characteristics and the adoption of workplace smoking policies. Health Educ Behav 2000;27:483-501.
37. Emmons KM, Biener L. The impact of organizational characteristics on smoking policy restrictions in midwestern hospitals. Am J Health Promot 1993;8:43-9.
38. Lasser K, Boyd JW, Woolhandler S, Himmelstein DU, McCormick D, Bor DH. Smoking and mental illness: a population-based prevalence study. JAMA 2000;284:2606-10.
39. Shi Y, Cummins SE. Smoking cessation services and smoke-free policies at substance abuse treatment facilities: national survey results. Psychiatr Serv 2015;66:610-6.
40. Data spotlight: U.S. Department of Health and Human Services. Rockville, MD: Substance Abuse and Mental Health Services Administration, 2014.
41. Himelhoch S, Daumit G. To whom do psychiatrists offer smoking-cessation counseling? Am J Psychiatry 2003;160:2228-30.
42. Krauth D, Apollonio DE. Overview of state policies requiring smoking cessation therapy in psychiatric hospitals and drug abuse treatment centers. Tob Induc Dis 2015;13:33.
43. Warnecke RB, Oh A, Breen N, et al. Approaching health disparities from a population perspective: the National Institutes of Health Centers for Population Health and Health Disparities. Am J Public Health 2008;98:1608-15.
44. Martinez-Gutierrez J, Jhingan E, Angulo A, Jimenez R, Thompson B, Coronado GD. Cancer screening at a federally qualified health center: a qualitative study on organizational challenges in the era of the patient-centered medical home. J Immigr Minor Health 2013;15:993-1000.
45. Liang S, Kegler MC, Cotter M, et al. Integrating evidence-based practices for increasing cancer screenings in safety net health systems: a multiple case study using the Consolidated Framework for Implementation Research. Implement Sci 2016;11:109.
46. Damschroder LJ, Aron DC, Keith RE, Kirsh SR, Alexander JA, Lowery JC. Fostering implementation of health services research findings into practice: a consolidated framework for advancing implementation science. Implement Sci 2009;4:50.
47. Institute of Medicine. Spread, scale, and sustainability in population health: workshop summary. Washington, DC: National Academies Press, 2015.

DOI: 10.1056/NEJMsb1609101